National Disaster Warning Center, Thailand

Information and Communication Technology

Gap Analysis Report

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Fostering Disaster-Resilient Communities through Science, Information, and Technology

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Executive Summary

The catastrophic Indian Ocean tsunami of December 26, 2004, shattered Thailand's previous record of natural hazard deaths by nearly a factor of ten and caused widespread destruction. In response, Thailand's Office of the Prime Minister formally established the "National Disaster Warning Center, Thailand" (NDWC) to enhance the country's disaster warning capabilities and readiness.

In this light, the U.S. Trade and Development Agency (USTDA) provided a grant to NDWC as part of the U.S. Government's broader support for the Indian Ocean Tsunami Warning System. The purpose of this funding is to provide Technical Assistance (TA) to the Thai Center towards enhancing its disaster management and warning capabilities. The Pacific Disaster Center (PDC) and its partners[1] (The Team) were then awarded a contract to provide the Technical Assistance to the Thai Center.

Purpose

As part of its Technical Assistance contract, PDC conducted an Information and Communication Technology (ICT) Assessment of the existing systems at the NDWC, and other key domestic data provider organizations. The goal was to document the baseline infrastructure and technical capabilities that could be used toward the establishment of a multi-hazard Decision Support Platform. Surveys, interviews, and data gathering were conducted in Thailand between January 30 and February 3, 2006. Other domestic agencies visited included the Thai Meteorological Department (Seismological Bureau), Royal Irrigation Department, and the Royal Thai Navy (Hydrographic Department).

In tandem with this effort are concurrent activities to develop a "Concept of Operations" (CONOPS) report in relation to the proposed Decision Support Platform, as well as a Data Inventory.

The Information and Communication Technology (ICT) Assessment - Overview

The main objectives of this report are to: a) identify the various disaster warning data feeds and linkages available to the NDWC; b) document the baseline ICT and related facilities; c) analyze the existing hardware, software, communications network infrastructure, and personnel to fulfill the functionality proposed by the PDC's solution and; d) in conjunction with NDWC technical staff, formulate a consensus regarding ICT gaps with respect to the NDWC's operational capabilities. Based on this gap analysis, The Team's technical experts will work with the NDWC Information Technology Director to develop an acquisition plan for equipment to be used as part of the overarching TA contract activities.

Accordingly, this report:

a) describes relevant background information, including the process and methodology used to derive the findings;

b) provides an overview of the NDWC and related national agencies and organizations;

c) details the proposed system architecture (which defined elements examined in the survey, as described below);

d) summarizes the ICT Assessment; and

e) presents key findings (including gaps) and recommendations.

A depiction of the *types* of analysis conducted before, during, and after the administration of the survey presented below in Figure 1. This analysis process formed the "underpinnings" of the overall report structure that is summarized above.

[1] PDC's partners are: Sun Microsystems, the Environmental Systems Research Institute (ESRI), and Lockheed Martin Information Technology (LMIT).

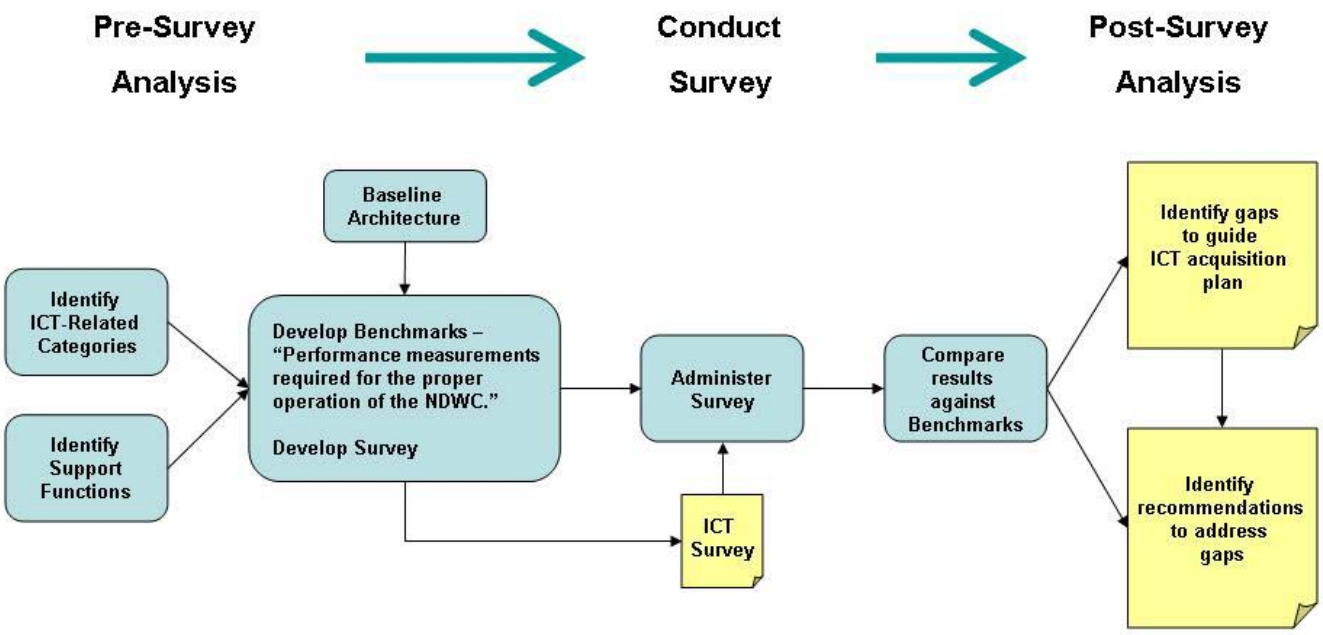

Figure 1: Types of analysis conducted before, during, and after the administration of the ICT Survey.

In order to identify gaps, the expert Team first devised a set of ICT-related categories that would directly impact the feasibility and effectiveness of the warning center's operation. Hosting Facilities, Communications Infrastructure, and Computing Resources were all considered to be crucial categories. Next, The Team identified supporting components that are important in the sustainability of the operation and the proposed solution. Network Security, System Processes, and Human Resources were all identified as important supporting functions. Next, ICT-related elements (such as phones, computers, etc.) and capabilities (such as Internet accessibility) were examined and categorized based on the above importance factors, and were assigned a performance measurement value, herein referred to as a "benchmark[2]". PDC utilized its previously-revised Integrated Decision Support System Architecture (developed in 2002-2003 under a contract with U.S. Southern Command (USSOUTHCOM)) to further define and refine these benchmarks.

For each of the above categories, The Team considered three different performance benchmarks: ***Minimal***, ***Recommended***, and ***High Availability***.

The Team then conducted a survey of the existing NDWC ICT elements and capabilities, compiled the results, and compared the findings against these benchmarks. The approach finally resulted *in the identification of gaps* that should be guiding the ICT acquisition plan for the TA contract.

Please note that this report not only examined the NDWC's ICT-related capabilities, but briefly considered the hazard data and information flow and the inter-connectivity to/from the national supporting agencies and organizations. This effort was guided by the Concept of Operations (CONOPS) document and input from Thai counterparts at the NDWC.

[2] Benchmarks represent performance measurements required for the proper operation of the warning center. These benchmarks were devised based on the TA contract proposed activities and solutions.

Summary of Findings

In summary, this survey finds that - for the most part:

- NDWC's ICT-related hosting/building facilities meet or exceed ***recommended*** specifications. This includes the Server Control Room, Operations Room, and related facilities within the building, however, the building requires upgrad to withstand frequent localized disasters.
- NDWC's client computing environments, general office services, and communication infrastructure NDWC meet or exceed ***minimum*** requirements. This includes PC workstations, office suite, office file and print services, the internal Local Area Network (LAN), and web and fax servers.
- NDWC's network (electronic) security and human resources and skill, however, are barely sufficient to meet the minimum requirements, and require considerable attention. System processes also are urgently needed to ensure business continuity and operations, especially, in times of emergency.
- Most importantly, and as it pertains directly to the scope of the TA contract, specialty application servers and services represent the biggest gap at the NDWC, at the moment. The NDWC lacks basic automation of data processing that can greatly enhance its abilities to analyze events and issue warnings.

Finally, it is appropriate to note that the NDWC also has a basic gap in establishing (dedicated) data communication links to supporting agencies. It is crucial to the operation of the warning center to have reliable connectivity to (national and international) hazard data providers.

Other Key Recommendations

- Invest in redundant communication paths (not necessarily vendors) to/from the NDWC. This ensures continual operation during emergency outages.
- Create of "Highly Available" systems that have sufficient redundancy to guarantee that all key technical functions within the NDWC are always operational. This requires a dedicated team of full-time staff working for the NDWC on this issue.
- Establish industry-standard (and highly available) network security elements that are maintained by a qualified team of technical professionals. Network security elements include systems monitoring, firewalls, virus cleaning, spam filtering, backup/recovery and fail-safe redundancy.
- Invest in training both technical and non-technical staff on international languages to effectively communicate with foreign partners and counterparts. Regular "peer-to-peer" interactions over the hotlines must be integrated into exercises and drills to ensure that this process is functional during a crisis.

Introduction

Between January 30 and February 3, 2006, the Pacific Disaster Center (PDC) conducted an Information and Communication Technology (ICT) Assessment of the systems at the National Disaster Warning Center (NDWC), Thailand and other key domestic data provider organizations—including the Thai Meteorological Department (Seismological Bureau), Royal Irrigation Department, and the Royal Thai Navy (Hydrographic Department).

This section details: relevant background information, the purpose of this report, scope and limitations, process of gathering the information and the methodology used for the assessment, including the **benchmarks** used to identify gaps.

Background

On December 26, 2004, the magnitude 9.0 Great Sumatra Earthquake struck off the coast of Indonesia's Sumatra Island. The earthquake triggered a massive tsunami that caused catastrophic and unprecedented death and destruction along the coast of a dozen nations throughout the Indian Ocean basin. Over 230,000 people perished across Indonesia, Thailand, India, Sri Lanka, Myanmar, Bangladesh, Mauritius, the Maldives, Seychelles, Kenya, and Somalia.

The tsunami is now ranked as one of the most destructive natural hazard events in Thailand's history. It inundated the Andaman coast in Phuket, Pang-nga, Krabi, Trang, Satoon and Ranong, causing 5,396 deaths nationwide. Nearly half of the casualties were foreigners. In Thailand alone, the tsunami left 8,457 people injured, 2,951 people missing, and 880 children orphaned. The disaster caused more then 30 billion Baht ($750 million U.S.) in economic losses to the Andaman coast's tourism industry. Damage to property and coastal environments was severe.

As a consequence of this catastrophe, the National Disaster Warning Center (NDWC), Thailand was established under the order of the Office of the Prime Minister. Accordingly, the NDWC was established, funded, and open for operation within five months of the event.

Subsequently, the U.S. Trade and Development Agency (USTDA) provided a grant to NDWC as part of the U.S. Government's broader support for the Indian Ocean Tsunami Warning System (IOTWS). The purpose of the grant was to provide Technical Assistance to the Thai Center towards enhancing its disaster management and warning capabilities. The Pacific Disaster Center (PDC) and its partners (hereinafter refer to as "The Team") were then awarded the contract to provide Technical Assistance (TA) to the NDWC.

Under this contract, The Team is committed to the development of an integrated architecture for a multi-hazard disaster early warning and decision support platform to support NDWC operations. The platform will include a web-accessible Geographic Information Systems (GIS) map viewer, hazard event tracking and collaboration tools, and basic hazard modeling systems needed for disaster management and decision making.

In order to implement the proposed solution, PDC was set out to review the existing infrastructures, warning data, and emergency management processes and further, to develop a *gap analysis* report with regard to establishment of an enhanced integrated decision support platform. Based on the findings, The Team would then compose an integrated architecture and assess a strategic implementation plan for a multi-hazard solution, including detailed cost estimates. This report addresses the *gap analysis* task of the overall TA contract.

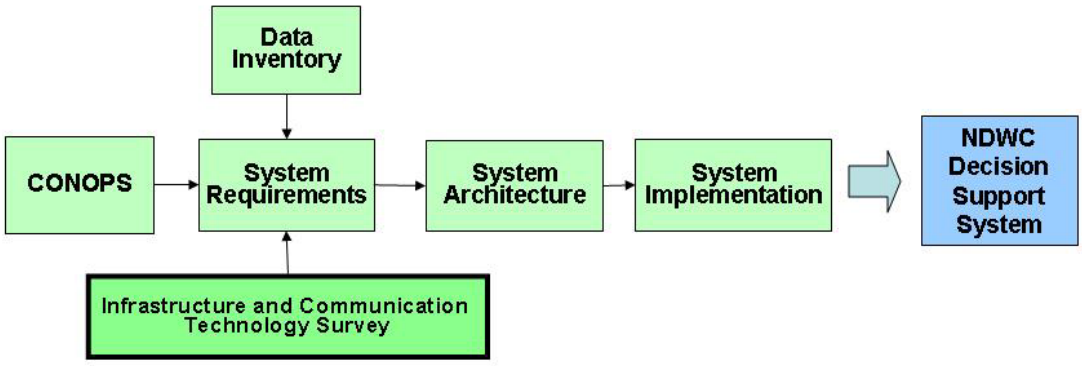

Figure 2: Principal Project Components for PDC's Technical Assistance to Thailand's National Disaster Warning Center

As shown above in Figure 2, the ICT Assessment (bold box), along with Concept of Operations and data inventory will contribute to the system requirements that guide the development of the proposed system architecture. After the completion of this architecture, systems will be installed, configured, and integrated to provide the Decision Support Platform proposed within the scope of this project.

Purpose of the Report

The purpose of the report is to identify and document the (existing) hardware equipment, software, and communications network at the NDWC as they relate to the development of a multi-hazard early warning and decision support platform. Additionally, this report examines and compares the existing capabilities with standard "benchmarks" required for the operation and maintenance of such platform, including—but not limited to—the infrastructure, security, human resources and skills required for the operation and maintenance of the system. The result of this comparison is presented as a gap analysis summary within this report, and a set of recommendations to fulfill these gaps.

ICT Survey and the Data Gathering

Process

PDC had developed a detailed ICT survey that was used in the ICT capabilities assessment of the Association of South East Asian Nations (ASEAN) ten Member Countries[3]. The survey examined many ICT aspects of disaster information sharing amongst the participating nations, including Thailand[4]. This ICT survey was modified for use at NDWC, Thailand, and was shared with NDWC authorities. NDWC was then asked to comment on the survey and identify other key stakeholders and organizations that should be engaged during the administration of the survey. In turn, NDWC provided letters authorizing the visit by survey team to each agency.

[3] The ASEAN ICT survey and assessment was done in 2005.

[4] The ASEAN Committee for Disaster Management (ACDM) focal point in Thailand is the Department of Disaster Prevention and Mitigation (DDPM). The assessment report is available through the ASEAN Secretariat.

Next, PDC's ICT expert traveled to Bangkok, Thailand to administer the survey. The week-long assessment was facilitated and coordinated by NDWC, starting with an initial meeting on January 31, 2006. The meeting was attended by management and technical staff at NDWC, as well as members from the NDWC partner government agencies and consulting organizations. The initial meeting provided a venue to explain the role of the ICT survey within the context of the overarching Technical Assistance contract. During the meeting, PDC gave a presentation (also translated into Thai) followed by extensive discussions of the subject matter experts to clarify the issues discussed.

The core survey team was composed of the technical lead and admin staff (for translation) from PDC and the technical leads and supervisor staff at NDWC. The survey team met separately with the agencies involved at the initial meeting, during which the vision of the project was explained and the groundwork for the survey was established. This was immediately followed by a working session with the technical staff and administration of the detailed survey. Survey answers and the ensuing discussion generally determined team activities at each site, which included photography of key equipment and obtaining networking diagrams and other pertinent manuscripts. Where a visit to a specific agency was not possible, NDWC lead staff followed up with the subject agency and supplied PDC with a completed survey. All results were compiled by the PDC.

Methodology

Under the TA contract, The Team will develop and deploy a prototype multi-hazard early warning and Decision Support Platform. Initially, the platform is focused on tsunami and earthquake hazards, but the platform is to be scalable to cover other hazards in the future. The architecture for the solution is based on the PDC's Integrated Decision Support System (IDSS), developed in 2002-2003 under a contract with US-SOUTHCOM, and evolved over the years. The architecture includes an integrated suite of Geographic Information System (GIS) and hazard analysis tools, along with web-accessible GIS viewer and automated data processing and notification applications. For an effective solution, this base architecture requires certain ICT infrastructure.

The PDC expert team used the architecture to establish the minimum ICT requirement and computing capabilities, GIS platforms, data availability and processing needs, and communication alternatives needed for the delivery of warnings. These minimum requirements were then divided into various ICT categories and were used to determine the "benchmarks" applied in this analysis.

Once surveys were compiled, the results were compared with the benchmarks in order to identify strengths and the gaps in the existing ICT infrastructures. Recommendations were then made outlining how the gaps may be filled within the scope of the overall project. Below is a summary description of the ICT benchmark categories.

Benchmark Categories

The following is a brief description of ICT benchmarks categories used in this assessment. Each category plays an important role in the effectiveness of the proposed solution, and thereby influence the installation, implementation, and configuration of the proposed Decision Support Platform.

- Facilities: to include the general construction and properties of the NDWC building as they pertain to ICT functionality.
- Communications: to include data and voice communication options required for the operation of the center with regard to the proposed solution.
- Computing Resources: to include all (server and client) computing resources required for the operation of the proposed solution.

In addition to the above, The Team briefly examined the following related categories as they are essential to the operation of the warning center.

- Network Security: to include electronic security issues that will heavily influence the effectiveness of the proposed solution.

- System Processes: to include system processes, such as backup/recovery, that is required for long-term sustainability of the operation, as it pertains to the proposed solution.
- Human Resources: to include human resources that will heavily impact the health (and therefore, the effectiveness) of the proposed solution over time.

The above categories are explained in more detail in the subsequent sections.

Scope and Limitations

The scope of this assessment covers existing NDWC capabilities in terms of ICT hardware, software, communications infrastructure, and human resources relating to the deployment and operation of the Decision Support Platform. The most critical aspect of this survey concerns hardware issues that cover the basic network communications (where applicable), Internet connectivity, data centers, and the operational readiness of NDWC and supporting organizations. The software portion of the survey covers the operating systems in use, databases, and custom disaster management applications and GIS.

A section of the assessment is devoted to the disaster warning data sources available to NDWC, which are necessary for the situational analysis and dissemination of disaster warnings and advisories.

Please note that:

- Although the survey covers whether public notification systems are in place for disasters, whether a public education and outreach system is available, and whether the NDWC conducts or participates in regular disaster exercises, the assessment does not go into an in-depth analysis of the above.
- *Only funded improvements to and planned activities for the existing infrastructure at NDWC and partner agencies were covered in this report*. "Vision plans" and prospective annual upgrades that are subject to future budget availability were not considered. Similarly, informal, undocumented, and/or non-binding inter-agency agreements and arrangements were not studied in detail and were considered outside of the scope of this report.
- This assessment does not intend to address non-ICT constraints for information-sharing, including language barriers, national and local policies, organizational liabilities and treaties, and other non-technical common protocols for information exchange. It is the understanding of the authors that other programs are being considered to address these latter issues.

Finally, the authors have taken special care to include the results of all of their findings. Nonetheless, it must be noted that what is reflected in this document may not be viewed as an all-inclusive representation of the NDWC's capabilities. It is entirely possible that some key aspects of partner organizations and ICT relationships were missed due to the limited logistics allocated for this assessment.

Overview of the NDWC and Related Organizations

This section briefly examines the role of the NDWC and the partner organizations within the overall disaster warning framework, and as pertinent to ICT capabilities. For more detailed information on NDWC role and information flow, please refer to the NDWC Concept of Operation (CONOPS) report. Figure 3 depicts a summary of the overall capabilities and linkages discussed in this section.

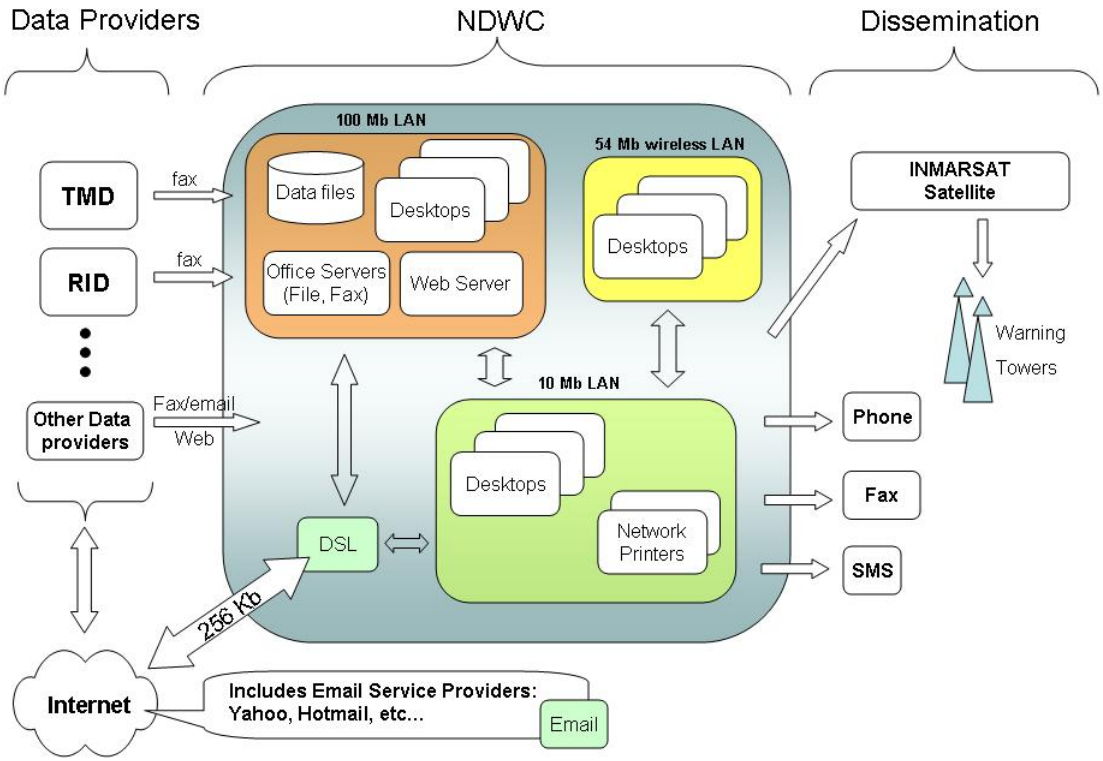

Figure 3: Summary of the overall capabilities and linkages discussed in this section

NDWC's overview and its ICT capabilities are provided below, followed by a brief discussion on several national data providers such as the Thai Meteorological Department and the Royal Irrigation Department.

NDWC Overview

Role

On May 30, 2005, NDWC was officially opened as the designated and the lead organization for receiving, monitoring, processing, and disseminating critical information and official government warnings. Information was envisioned to be disseminated to officials, emergency response agencies, and the general public on a "24-hour, seven-day-per-week" basis.

The major responsibility of the NDWC is to receive information related to earthquakes and other natural and man-made events. NDWC also analyzes data and issues warnings when necessary.

Information Flow

The "information flow" for the early warning system developed by NDWC consists of three components: 1) Information Sources (Input); 2) Evaluation and Decision Making (Analysis); and 3) Information Users (Output). This is depicted in Figure 4.

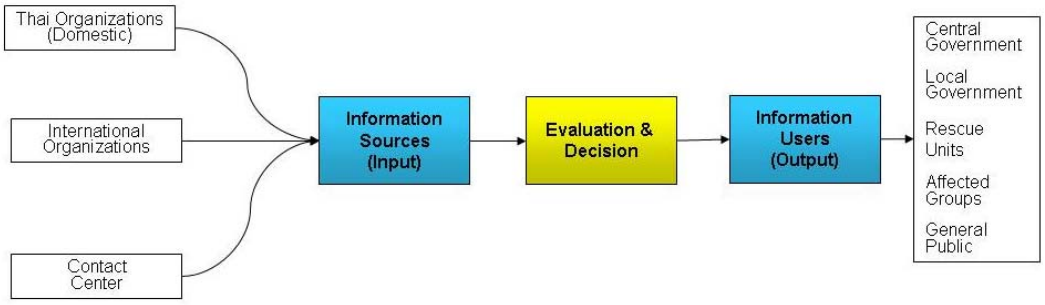

Figure 4: Information Flow depicting the Concept of Operations information flow for decision making within the NDWC's Early Warning System. (Source: NDWC)

The three "high-level components" in Figure 4 are further described below:

- Information Sources (Input) – Domestic and international organizations that provide disaster or disaster-related information, analysis, and/or warning information. Examples include the Thailand Meteorological Department and the Pacific Tsunami Warning Center;
- Evaluation and Decision Making (Analysis) – Analytical processes that NDWC has developed to validate hazard, warning, or disaster-related information, and to assess at-risk areas; and
- Information Users (Output) – Warnings or related information distributed to government authorities, rescue units, affected groups, and the general public by various modes of communication.

Overview of Facilities, Communications, and Hardware

NDWC infrastructure is centralized at its headquarters facilities near Bangkok at Rattanathibet Road, Bang Kra Sor Muang, Nontaburi, Thailand. Alert notifications for tsunamis can be issued from a single PC workstation at NDWC to 63 tsunami warning towers along the Andaman coast. Currently, a separate workstation is configured to conduct drills twice a day involving three (3) warning towers. The signal is first transmitted via the Internet over Secure Socket Layer (SSL) to the INMARSAT satellite communications system, which triggers the warning towers along the coast to issue voice commands in Thai and English. Outbound messages can also be delivered to key officials by telephone, fax, and cell phone text messages. A television studio within NDWC allows for the capability to hold live media briefings, when needed.

Early warnings can be received at the NDWC from media through twelve (12) live television monitors installed; or the general public through thirty (30) call center telephone lines that have at least five (5) operators available at any time; or various Thai and international agencies through dedicated phone hotlines or by fax. The call center can be reached by dialing the number "1860" from anywhere in Thailand.

An Integrated Voice Response (IVR) system has been installed at the call center. However, the IVR has yet to be configured to utilize all key features that could be useful to call center agents. Currently, the IVR simply plays a recorded "welcome message" to callers.

All phone lines are public network land lines. No satellite, Internet, or cellular phones exist for communications to back-up the public land lines. A single fax machine, receives all official disaster warnings directly from partner agencies, such as the Thai Meteorological Department. There is another fax machine in the administration office, which may be used to "back-up" the fax machine in the command center. There are no other direct data links for incoming disaster warnings.

All equipment is located in a single general-purpose building that is not specifically designed to withstand natural or man-made disasters. Power is reliable (the only outage during the last year

was scheduled in advance with the highway and electric authorities for one day due to road construction.) All staff work areas, including the control room, have air conditioning.

NDWC's control room has raised flooring with floor boards, overhead mounts for additional wiring, equipment racks, and Uninterruptible Power Supplies (UPSs) that can support up to 25 minutes of operation at full load. If required, this space has room for at least three (3) additional equipment racks six (6) feet in height. A back up generator can support the entire facility for eight (8) hours on a full tank of gasoline.

Public Internet access is provisioned through a 256K Digital Subscriber Link (DSL) provided by the Communications Authority of Thailand (CAT) and the Telephone Organization of Thailand (TOT). The telecommunications industry in Thailand is run as a monopoly with TOT overseeing the domestic telephone network and the CAT regulating international calls and circuits to the Internet. All Internet Service Providers (ISPs) are required by the government to be partially owned and operated by CAT. Internet service at the NDWC is not reliable, with outages experienced at least once a month lasting multiple hours. There is no dedicated service number for CAT or TOT for the NDWC and the general practice is to simply wait for Internet connectivity to be restored.

Within NDWC there is a 10/100/1000 Mega Bit Ethernet Local Area Network (LAN) supporting 34 PC workstations and two (2) laptops. There are typically 20 active users on the LAN. There are 39 user accounts, but they are function-based instead of individual accounts with assigned roles. There is no email server, and most staff members receive official email at personal accounts with companies, such as Hotmail and Yahoo. ***The systems are frequently infected with malicious software and content, such as viruses, spyware, adware, worms, Trojan Horses etc***. There are no scheduled backup, stand-by, or recovery plans for any workstation, including the one used to issue the tsunami alerts.

The most critical components are the warning tower and fax server workstations. Both are Intel-based as are the majority of NDWC's workstations and servers. There is one UNIX (Sun 240) server designated as a web/mail server. All systems have been operational for less than a year and are less than three (3) years old.

NDWC's Thai language web site, http://www.ndwc.or.th, deployed in May 2005, currently has a single static HTML page posted within an Apache server. The URL may change from "org" to "gov" later in 2006. Additional content is in the development stage using Hypertext Preprocessor (PHP). However, there are no major functional update(s), such as dissemination of any disaster information.

Overview of Software Applications

All other workstations are running Microsoft Windows XP (Thai Version). Although Oracle and mySQL software are available, there are no active instances of any databases serving NDWC current operations. Office productivity software is limited to Microsoft Office (Word, Excel etc). PHP is used for web site, and Notepad is used to maintain content. The ArcView GIS client software is used to locate epicenter and affected areas for any earthquake greater than 3.0 magnitude that occurs in Thai territory—defined as 720 kilometers within Thai coastline. The Unix operating system is used in one (1) Sun 240 workstation.

Support Personnel

The head of NDWC's Information Technology (IT) Department has more than 30 years experience, and the department's webmaster has over 12 years technical experience. In addition, systems support functions are performed on an informal basis by at least three (3) other staff members. However, no NDWC staff is dedicated to maintaining the computer network. At the time of the visit, all personnel were deputized to NDWC from partner agencies, such as the Department of Disaster Prevention and Mitigation (DDPM) and the Department of Mineral Resources (DMR). Computer users lack any "help desk" support. There are no standard operating procedures to update the operating system and anti-virus software. Although all hardware do in fact have clear inventory tags, we were unable to verify that all software licenses were in place for all workstations. With proper access to licensing information, any full-time support staff hired by the NDWC will be able to download the latest operating system patches

available from software vendors, such as Microsoft, McAfee, and Norton on a regular basis to keep the computers virus free.

Other Related (Planned) Funded Activities

A real-time seismic monitoring station will be installed at NDWC headquarters in Nonthaburi. The system is being bid out as a distributed open-architecture UNIX-based acquisition, analysis and management software system. It is designed to provide a comprehensive set of environmental monitoring data and processed information in real-time, focusing on monitoring seismic events from local/regional, national, and global networks and arrays. The system will provide full functionality for seismic network and array operations and control, including real-time data acquisition from field digitizers, interactive control of field equipment, system state-of-health monitoring, real-time automated data processing capabilities, including detection, selection, archiving, seismic event location, and association. Interactive and batch processing, the system will offer information system functions, automated distribution of raw data and processed results, batch mode seismic array processing, and a powerful development toolkit for extending and customizing the system.

Functionally, the software system being purchased will be able to determine the epicenter, depth, magnitude, and time of the earthquake "immediately and automatically" after an earthquake is reported by field sensors. No less than 90 data channels will be managed simultaneously (parallel processing). In addition, the system will be able to generate, import, and export other scientific data pertinent to seismic research and earthquake engineering. The management software will feature a rich Graphical User Interface (GUI) that meets the Cascading Style Sheet version 3.0 standard and will enable access to all capabilities of the software application, as well as the associated Relational Database System. The system will notify NDWC personnel via a pop-up message on computer screen, a clearly audible alarm hooked up to the NDWC LAN, and key offsite staff via mobile phone, land-lines, and email. Finally, all data generated by this system will be displayed on the NDWC web site hosted within its Nonthaburi headquarters.

In addition to the seismic monitoring system, NDWC has regular office computer upgrades planned on an annual basis, depending on funding and other resources approved for its ongoing operations.

Related National Agencies and Organizations

There is continuing thought regarding the need for NDWC to gain direct access to "field" hazard data sensors, and discussions centering on whether this approach would enhance the Center's warning capabilities. The seismic monitoring system discussed above is an example of a step in this direction. On the other hand, many believe that in most cases, sensor data requires analysis before it can be interpreted and useful (e.g., interpreting radar data for weather related analysis). As such, they recommend that NDWC receives the analyzed data from national expert agencies and organizations. This latter approach is also consistent with receiving data from regional and/or international agencies providing hazard data for events occurring outside of Thailand's national borders (e.g. from distant tsunamis triggered by earthquakes).

At this time however, the most realistic operational scenarios involve NDWC coordinating closely with a number of Thai and international agencies that have core competencies in and provide data for particular hazards. Subsequently, this assessment considered organizations and departments that may collaborate with the NDWC during a crisis. The primary role of these related organizations is to provide early hazard (and in some cases, warning) data and, possibly, expert analysis to NDWC. Established in the aftermath of the December 2004 tsunami, NDWC now has the sole legislative authority to issue alert notification based on these early warnings and expert analysis independent of where the analysis is actually conducted.

The organizations/departments considered in this report are:

- Thai Meteorological Department (TMD)/Seismological Bureau
- Royal Irrigation Department (RID)/Water Management Division
- Royal Thai Navy/Hydrography Department
- Department of Mineral Resources

- Department of Disaster Prevention and Mitigation

The ICT assessment of each organization below is focused on (and limited to) how that particular entity provides data to NDWC, especially as an early warning data provider to NDWC headquarters or one degree of separation from the NDWC. Typically, each of the following organizations has direct access to field instrumentation in order to collect hazard data. Although some organizations may have conducted alert notifications to the public and media before NDWC was constituted in April 2005, it is now NDWC's responsibility to represent the Thai government in issuing alert notifications based on data from these agencies.

Thai Meteorological Department /Seismological Bureau

TMD is the lead organization for gathering, interpreting, and forecasting weather data. Based on this capability, TMD generates emergency warnings related to floods, tropical cyclones, wind, high surf, haze, and drought.

A Seismological Bureau within TMD supports NDWC with seismic data. However, the only current ***data*** linkage is by fax. Although TMD receives information from various data links, it is able to transmit this data to NDWC only by fax.

Although TMD systems cannot currently provide dynamic electronic data, there are plans to collaborate with NDWC in this manner as soon as there is such a capacity on both ends. For instance, TMD is providing data link from Chiang Mai Seismic Station (CHTO) via the Internet in real-time to Albuquerque Seismological Laboratory (ASL), which in turn makes the CHTO seismograph available online at http://aslwww.cr.usgs.gov/Seismic_Data/telemetry_data/CHTO_24hr.html.

Raw data may be then retrieved from ASL and USGS in near real-time via the Internet. Another web site, http://ida.ucsd.edu/Tools/Orbmon/orbmon_CDP1hr.php, shows earthquake wave form in real-time in the Indian Ocean from Sri Lanka (PALK), Diego Garcia, COCOS (Australia) shows a signal every once every 150 seconds.

TMD is actively working with agencies like the USGS to modernize its capabilities. The existing 25 station network, with only 11 stations is proposed to be expanded this year to 30 digital stations.

As shown in Figure 5 below, there are eleven (11) digital and fourteen (14) analog seismic stations in Thailand. Three (3) digital stations are not operational. The future network will have 30 digital stations.

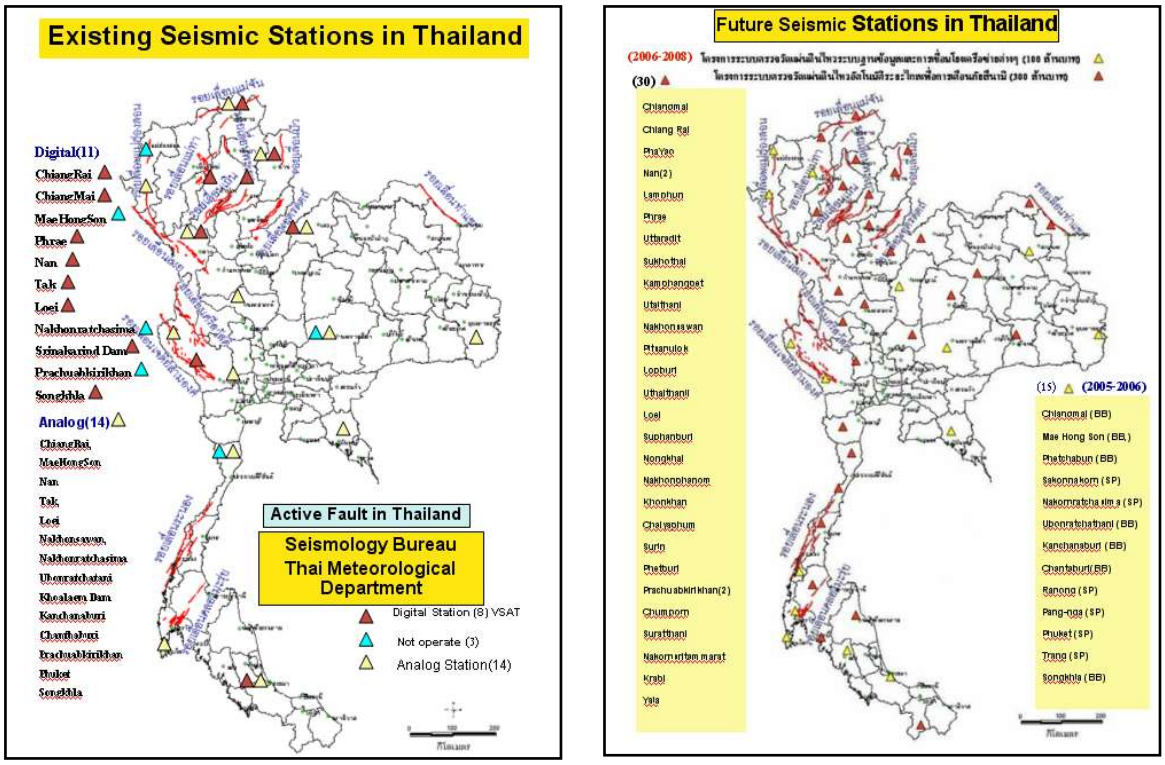

Figure 5: Existing and Future Seismic Stations in Thailand

The Seismic Monitoring Center is composed of a network of computers hooked up by satellite to field stations in Thailand. As shown in Figure 6, Data Acquisition Systems (DAS) at various locations have seismic monitors of the Short Period (SP) or the Broadband (BB) type "hooked up" to a Personal Computer (PC) where the raw data is first consolidated for transmission. The processed information is then transmitted from the PC to the satellite, first passing through a router and then via the antenna's Indoor Unit (IDU). As noted above, this system is being modernized and, through software upgrades at NDWC, will expand to link via the Internet to seismic stations in the Indian Ocean affiliated with Incorporated Research Institutions for Seismology (IRIS) and also those operated by the Malaysian government.

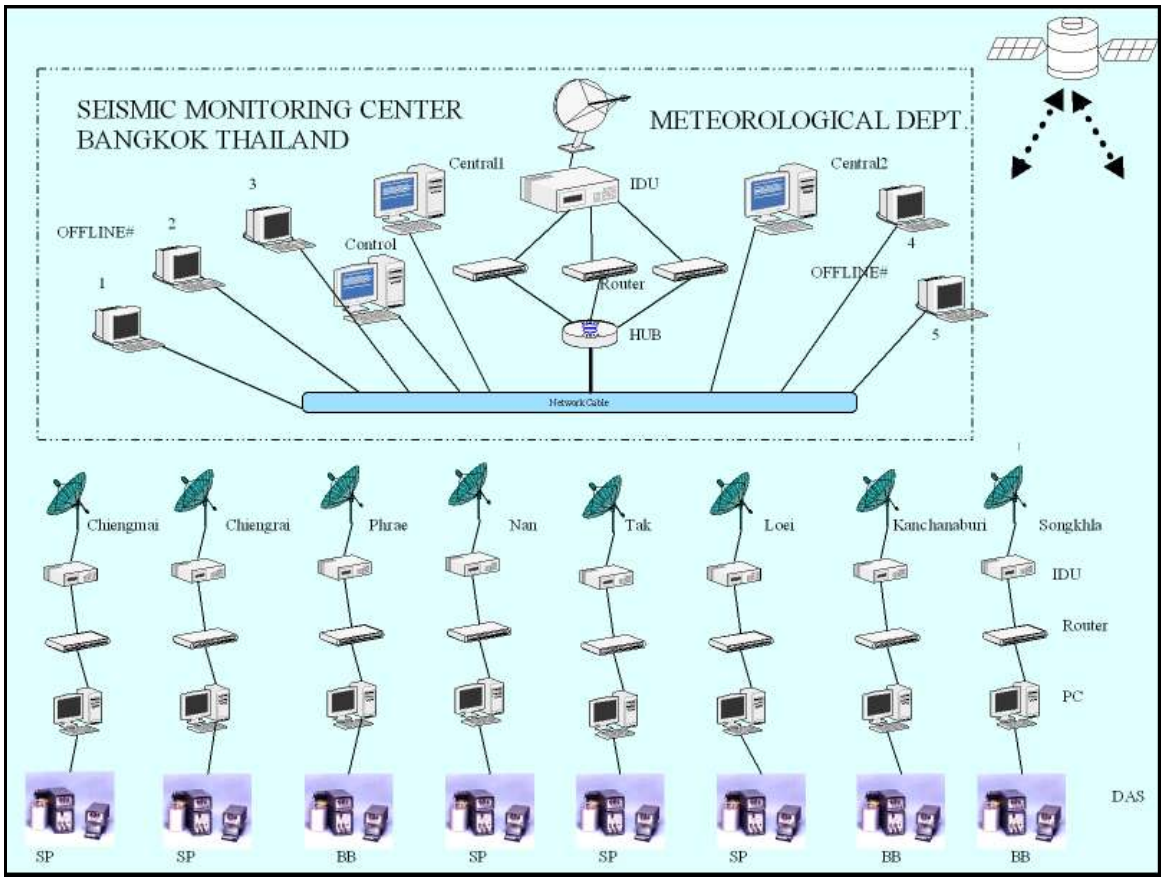

Figure 6: Seismic Network Infrastructure

Royal Irrigation Department (RID)

The Royal Irrigation Department is the nation's water authority with responsibilities to address a wide range of issues to include storing and conserving, regulating, distributing, releasing or allocating water for agriculture, energy, domestic consumption, industry, as well as the prevention of water damage, and inland navigation within irrigation areas.

RID has an extensive network of more than 1,000 inland water level stations that gather water level data in all 75 river basins in Thailand. These water stations collect data every 15 minutes. The data is consolidated at the Water Management Division starting at 7:00 a.m. each day and completed by noon. (Therefore, by noon each day, a snapshot in time of water levels across all of Thailand is available in raw data format.)

Floods are, by far, the most frequent problem in Thailand. The assessment team was reassured by the IT Director that RID has the capability to both "push or pull" the raw data to an approved remote computer, such as an NDWC server by text File Transfer Protocol (FTP). An "alternate" RID web site, www.kromchol.com, has been established to disseminate real-time water level data, but it needs a login and password authentication to access the information. In addition, it is desirable that the data be human readable, as well as the desired machine readable text file required for automated processing.

Royal Thai Navy/Hydrography Department

The Hydrography Department of the Royal Thai Navy has nine (9) tide gauge stations in the Andaman Sea of which six (6) are coastal stations, i.e. within 35 miles of coast, and three (3) are deep sea stations. The department has eleven (11) analog tide gauge stations in the Gulf of Thailand. In the "normal" mode, the tidal gauge stations transmit data every 15 minutes with transmissions every one (1) minute in the "urgent" mode. In addition to weather data from TMD, the Department also has access to specific meteorological data monitored by the Navy

specifically for routing sea vessels. A United States Air Force seismic station in Chiang Mai complements data from TMD (Seismological Bureau).

The primary mission of the Hydrography Department is to record ocean level data and generate forecasts of wave and water level data in the vicinity of Thailand. Annual forecasts are published by the Department in "Tide Tables Thai Water", which cost 80 Thai Bhat ($2US). The almanac made available to the ICT assessment team in early February 2006 has water predictions for all Thai waters through November 2006. Tidal analysis and predictions are made by the Harmonic Method, the most widely applied method of tidal prediction, which is the method also used by the U.S. National Oceanic and Atmospheric Administration to generate tidal forecasts. Harmonic analysis of water levels is based on the calculation of the gravitational influence of the sun and the moon. These celestial bodies attract all items on Earth because of their mass and the resulting gravitational forces. This influence is most significant on oceans as they have a large amount of free moveable water. Because the orbits of the Earth and the moon are periodic, it is possible to make accurate longtime water level predictions. The almanac clearly states that "abnormal" weather conditions, such as wind, are factors that may affect the accuracy of such predications to "some minor" extent. This margin of error is not specified.

During discussions with the ICT assessment team, Navy staff mentioned using the Princeton Ocean Model, which is a "finite element" model, used for water level and ocean current modeling in coastal waters. Finite element models are used in various disciplines, including civil/structural, and typically require supercomputers to generate results in a reasonable time for real-time applications. It is unclear if the Department has access to such a facility to use this model effectively for NDWC.

Staff was able demonstrate three dimensional modeling using ESRI GIS software. The demonstration included "before" and "after" scenarios created from data received from the December 2004 tsunami.

The prospects are excellent in terms of data linkages to NDWC. Each tide gauge station will have individual Internet Protocol (IP) data enabling harvesting of the data over the Internet. However, it is unclear when such a capability will be operational.

Department of Mineral Resources (DMR)

The ICT survey team was not able to visit Department of Mineral Resources (DMR) during this assessment. However, PDC was invited to visit DMR as a part of Association of South East Nation (ASEAN) Disaster Information Sharing Network (DISCNet) assessments in 2005. Even though there is no current data linkage with NDWC, DMR contributes significant resources in staff time and other ICT elements to NDWC. However, DMR is a critical source of early warning and advisory information for landslides and, therefore, has a support role to the operation of NDWC in a truly multi-hazard mode.

Since DMR has been in existence for more than 100 years, it has a substantial legacy of forging Memorandum of Understandings with various agencies, such as the USGS for data sharing. NDWC can benefit by having a suitable agreement with DMR to receive this information.

DMR's primary mission is not disaster related. It serves primarily as an geological fact-finding agency that predominantly studies and researches mineral deposits and fundamental geology. Application of the mentioned activities include collecting, monitoring, analyzing, and providing geological understanding about natural resources condition, issues, and problems. From a disaster management perspective, DMR extrapolates weather information from TMD and its extensive GIS-based geological databases to determine and minimize risks in landslide prone areas of Thailand. DMR also conducts rural teach-in campaigns to increase landslide awareness. DMR's capabilities include a planned call center that is focused on geological disasters, including landslides.

Department of Disaster Prevention and Mitigation (DDPM)

The vision statement of the Department of Disaster Prevention and Mitigation (DDPM) states that the Department "is the principal government agency designated to shoulder the task and responsibility on disaster management." Headquartered in Bangkok, DDPM was established

within the Ministry of Interior in October 2002 and has a total of 2,272 civil servants and 2,339 permanent employees nationwide.

DDPM is a consolidation of previously-existing agencies with overlapping responsibilities including the: (1) Civil Defense Division, Department of Local Administration; (2) Office of National Safety Council of Thailand, Office of the Prime Minister; (3) Division of Disaster Victim Relief, Department of Social Welfares, Technical Assistance Center, Community Development Regional Centers 1 through 9, Department of Community Development; and (4) Accelerated Rural Development Department.

DDPM has both national and provincial-level Civil Defense plans. The national plan is formally revised every three years while the others, including evacuation plans, are revised annually. Regular exercises are conducted at least once every year at the provincial level for floods and fires. There is an extensive nationwide public address system, which has over 6,000 speakers and provides coverage to all villages.

Civil Defense volunteers are trained to convey disaster management information to the general public. A Disaster Prevention and Mitigation Academy was established in DDPM to train staff and ordinary citizens. DDPM has also developed several manuals and brochures for public outreach.

Systems Architecture

This section provides a brief summary of the major components of the proposed Decision Support Platform. This architecture was used as a baseline to identify the ICT benchmarks, and then to serve as the guiding principle for the ICT assessment and gap analysis.

A major goal for this architecture is to provide an *integrated framework* through which hazard analysis and warning data can be automatically processed and effectively presented. As such, the system would allow for rapid decision making regarding responding to disasters and warning the public, as necessary. It therefore combines various web and GIS technologies to facilitate processing the data, visualizing the event, and facilitating collaboration and rapid sharing of the hazard information.

Server Side Systems Architecture

The proposed system architecture supporting NDWC multi-hazard disaster analysis applications consists of the following main components:

- Web Server – for wide (web-accessible) data dissemination;
- Applications Server – for providing a base platform for the proposed applications;
- Spatial (GIS) Server – for providing a platform for spatial data, and to enable web-based map services;
- Dynamic Data Processor – for automated (near real-time) processing of hazard data; and
- Relational Database Management System – for organizing and serving large amount of data.

Figure 7, below depicts the above general components.

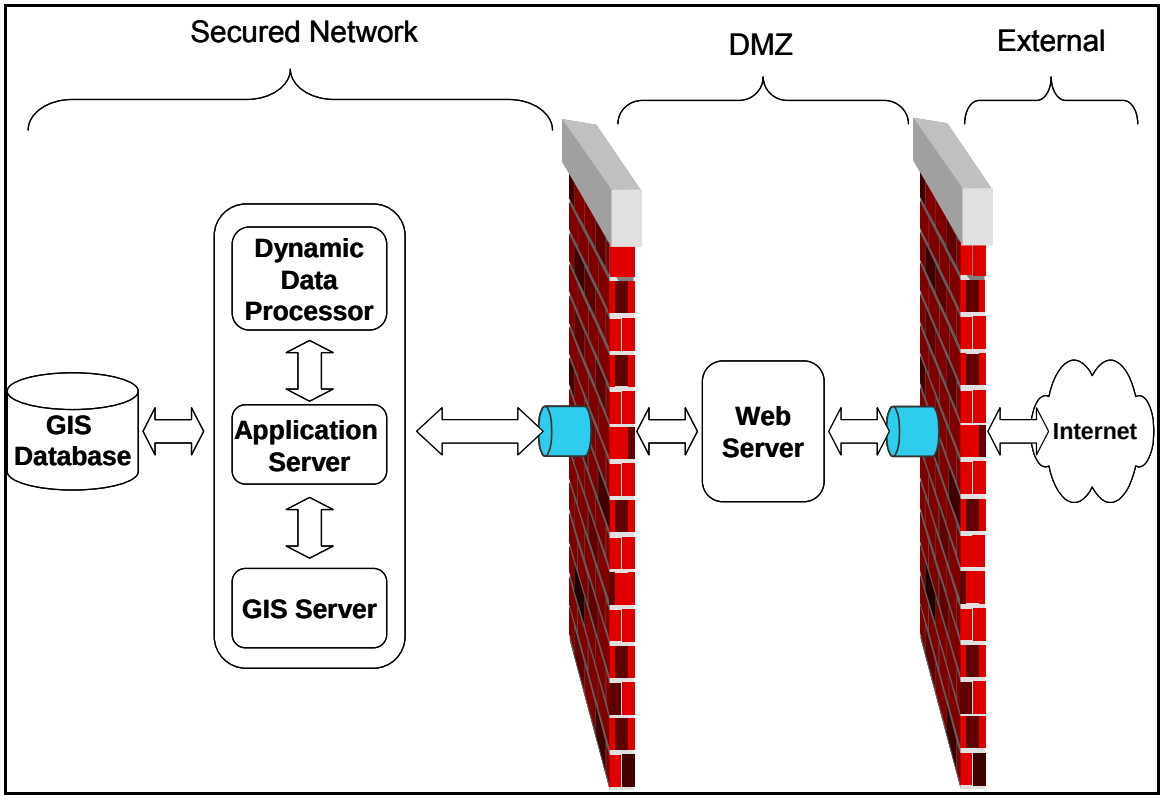

Figure 7: Server Side Systems Architecture

The web server is the chief gateway into the applications and data for NDWC clients. It will be located in a "De-Militarized Zone" (DMZ) between the internal and external firewalls, accessible over the public internet. The web server connects to the rest of the system through a specific

internal port within the firewall as shown in Figure 7. This architecture is generally suited for secure applications and data.

The Dynamic Data Processor (DDP) ingests real-time data from various (NDWC) data providers, such as TMD, RID, and/or USGS. The applications server and spatial server will house application software provided by The Team. Along with the database system (featuring Oracle) the application server and the map server collaborate to serve NDWC clients with data and maps required for disaster management.

Web Server

As shown in Figure 7, the web server is usually the logical gateway into an enterprise web application environment. It is designed to respond to requests in the standard Hyper Text Transfer Protocol (HTTP), typically delivering fast static web content over the Internet.

NDWC already has a web server, a Sun Fire V240 Server, which exceeds the minimum recommended requirements.

Applications Server

The applications server is similar to the web server in the sense that is delivers web content. However, unlike the web server, the applications server is optimized to deliver dynamic content based on platforms, such as Java Enterprise Edition (J2EE), database access etc. It can run on the same machine as the web server, but is best located on a separate machine separated by a network firewall as shown in Figure 5.

The applications considered under the Technical Assistance (TA) contract will require a Sun Fire V240 or equivalent with 73 GB disk and 4 GB RAM available to applications above and beyond what is required by the operating system and associated memory-resident programs.

Spatial (GIS) Server

The spatial server is optimized to deliver maps and features from a GIS database to the applications. This service can be co-located with the application server hardware (above), but for high availability, it is best to have it installed on a separate hardware that is as functional as the applications server. The GIS server software solution is provided by ESRI—the leading world-wide vendor in this market and one of the PDC Partners on the TA contract.

Dynamic Data Processor

The Dynamic Data Processor (DDP) interfaces with the outside world over various protocols to get data from external entities. This data may be pushed to the DDP or the DDP itself may initiate a pull from the source.

Minimum recommended hardware configuration for the DDP would be the Sun Fire V120 server. Large configuration would be one (1) CPU @ 650 HMz, 1GB RAM, 2 x 73 GB 10000 RPM disk drive and two (2) NIC cards. Operating System: Sun Solaris.

Add-on freewares for automated processing of hazard data include: GNU compiler, Perl, GDAL, DEGRIB, GMT, PROJ, Expat, TCL/TK. Software that needs to be purchased would include DataDirect ODBC driver package (< $500) and the ESRI ArcSDE client.

Relational Database Management System Server

The database server for the geospatial data repository processes many simultaneous requests for large geospatial images. For this to operate effectively, it requires fast data retrieval, significant memory cache, and a fast CPU processing. Typical geospatial database servers have 300 GB to 10 terabytes of storage, 8-48 GB of memory, and multiple CPU's running at a rate of 2.8 GHz or faster.. The specifications recommended for this server are Sun-Fire 480R 4 X 750Mhz CPU 8Gb Ram with TB Storage Array. To maximize transaction support under mission critical applications, NDWC must use Oracle 10g Release 2 Enterprise Edition or equivalent software. To work with GIS, we recommend ArcGIS SDE 9.2.

ICT Assessment

In order to assess the ICT capabilities of the NDWC, The Team categorized the survey results into the following main components, and evaluated each category separately:

- Facilities: This category includes general facilities construct and infrastructure, including site redundancy, ICT and server space, and power availability and reliability.
- Communications: This category encompasses (availability and reliability of) various channels of voice and data communications and protocols including phone, fax, SMS, satellite, email, broadcast media, Internet access, the internal Local Area Network (LAN), and dedicated data access including access to the external Wide Area Networks (WAN) . Please note that hazard data inventory is covered under a different task within the TA contract (and currently on-going), but this assessment briefly considered "inter-agency connectivity" between NDWC and some of the data providers. This is needed to ensure reliable communication between the data providers and the warning center
- Computing Resources: This category covers server-side and client-side computing resources and equipment needed for the Decision Support Platform, and it is divided into the following two subcategories:
    - Services and Servers: This subcategory covers various logical services that may physically reside in one or more server (hardware) platform(s). The server-side containers include services such as the web, application, spatial engine, database, dynamic data processor, and the fax.
    - Workstations: This subcategory considers the client-side computing power and working environment, including personal computers, laptops, and monitors. .

In addition to the above explicit survey categories, The Team briefly examined the following as they are essential to the operation of the warning center.

- Network Security: This category considers electronic security concerns that are needed for a healthy system environment such as availability of firewalls, intrusion detection, malicious software (e.g. viruses, worms) detection and prevention, email and SPAM protection.
- System Processes: This category considers processes and applications needed for maintaining a reliable computing environment such as network alarm monitoring, backup/recovery processes, and standby/redundancy for the critical equipment.
- Human Resources: This category covers the skill sets needed by full-time NDWC staff to operate and maintain the systems environment. These skills include webmaster, systems administration (of various types) and GIS0-based modeling, simulation, and imagery analysis.

Please note that these later categories do not impact the initial deployment or operation of the platform, but are critical to the long-term sustainability and continuity of the solution-set and the operating environment of the NDWC.

Benchmarks

For each of the above categories, The Team devised a *varying performance benchmark* and a *corresponding measuring unit* that is required for the proper operation of the warning center. To this end, The Team considered three options:

a) Minimum Requirement - The minimum configuration needed for testing and/or proof-of-concept type deployment;

b) Recommended – The recommended configuration for a reasonably efficient systems that would allow for growth; and

c) High Availability (H/A) – The high availability scenario for most optimal operation including fail-over/hot stand-by for the recommended configuration.

The expert team then compared the ICT survey results (i.e., existing capabilities) in each category to the above benchmarks, and produced the gap analysis report.

Table 1 below summarizes the benchmarks used in this ICT analysis. The use of "N/A" "Not Applicable" meaning that the benchmark is not highly relevant to the analysis.

		Benchmarks		
		Minimum	**Recommended**	**High Availability**
Facilities	**Server Room**	Availability	Separate A/C & growth room	Raised floor & Redundant loc
	Power	Availability	Reliability	Backup Generator
	Operation Room	Availability	Networked & Large Displays	Multiple locations
	General Rooms	Meeting	Cafeteria	Press Room
Communications	**Phone**	Availability	PBX	Redundancy
	Fax	Availability	Server	Redundancy
	SMS	Availability	N/A	Redundancy
	Satellite	N/A	Availability	Redundancy
	Email	Availability	In-house capability	N/A
	Public Media	Availability	N/A	N/A
	Internet	Availability	Broadband and Reliability	Redundancy
	Dedicated Access	Availability	Comm Path Redundancy	Data Provider Redundancy
	Local Area Network	Availability	Wireless	Server Redundancy
Computing Resources	**Office Servers**	Availability	Scalable	Stand-by
	Office Services	File, Print, and Web	Fax	Stand-by
	Specialty Servers	RDBMS, GIS, Application	Stand-by	H/A Options
	Client workstations	Less than 3 yrs old	Office Suite & GIS client apps	Modeling apps
Network Security				
	General	Firewall	Virus protection	Monitoring and detection
System Processes				
	General	Backup/restore	Off-site storage	Traffic monitoring
Human Resources				
	General	IT Admin	GIS Analyst	Modeling Specialist

Table 1: Benchmarks used in the ICT analysis

Gap Analysis

Facilities

NDWC is located in a single story building near Bangkok at: Rattanathibet Road, Bang Kra Sor Muang, Nontaburi, Thailand. The building is not specifically designed to withstand natural or man-made disasters, but it is reasonably solid. There is a gateway to the yard and a main (guarded) entrance to the building, and two secondary exits. The building has a small cafeteria and a small lounge that can support extended-hours operations. Furthermore, the building has a number of meeting rooms and a mid-size (capacity about 20 people) media briefing room to accommodate press announcements.

The power to the NDWC is stable and reliable. All server computing hardware and telecom switches are placed in a raised-floor control room next to the Emergency Operation Room, ensuring maximum reliability connection to the client workstations. The control room is equipped with Uninterruptible Power Supplies (UPSs) that can support up to 25 minutes of operation at full load. A back up generator can support the entire facility for eight (8) hours on a full tank of

gasoline. There is enough room within the control room to support *gradual growth*. A vacant building in the court yard also allows room for *sudden growth*.

In general, the facilities meet or exceed the recommended requirement.

Communications

Phone System: Currently, NDWC has an operational call center with 30 lines manned by five (5) agents, various departmental hotlines, and one (1) phone for international agencies.

This clearly exceeds the minimum requirement of at least one phone line. The recommended configuration would simply use the existing system to its full installed capability. For instance, the (already purchased) Integrated Voice Response (IVR) can be configured better to effectively back-up and/or complement the call center telephony operations. This assessment also found that some of the hotlines would be more useful if they are used and/or tested on a regular basis, to avoid a last minute "scramble" during an emergency. For maximum availability, the phone system should be able to operate during an emergency when land-line traffic is expected to be at peak capacity. In general, it would be ideal to organize both multiple inbound as well as outbound voice options. To ensure backup/fail-over transmission, alternate channels, such as Voice over Internet Protocol (VOIP) and a dedicated satellite wireless channel, must be considered. To interface more effectively with international agencies, multi-lingual operators fluent in English, Japanese, and all major ASEAN languages would be useful.

Fax: NDWC meets the minimum requirement of having a single fax machine. It exceeds that minimum requirement by having a fax server with a hot backup/standby. As with the phone system, the recommended action would be to use the existing system to its fullest capability by configuring for inbound fax alert notification, hooking up additional fax machines to the system, and instituting regular automated tests to ensure the system is always functional. For maximum availability, there could be dedicated fax hotlines to key agencies. In addition, this could augment human readability with machine readability. Fax can become an effective input module for providing automated raw data to the proposed dynamic data processor (DDP). This would require installation or activation of Optical Character Recognition (OCR). The OCR DDP link would be most effective along with policy-level understanding with key data provider on data formats for fax transmissions.

SMS: At least one cell phone or personal digital assistant (also called a PDA, such as a Palm Pilot) or equivalent handheld devices may be used to transmit text messages using any Internet Service Provider (ISP). NDWC has access to free web-based SMS outbound service to transmit alert notifications. The recommended configuration would use a dedicated in-house email server with a simple predictive dialing application installed on the NDWC intranet or even a popular email client, such as Microsoft Outlook. For high availability, the critical aspect would be off-site/ third-party providers with guarantees for Quality of Service (QoS). In this scenario, NDWC would be responsible for creating the alert notification, but a reliable third-party carrier would be responsible by contract to distribute the message to the intended recipients in real-time or within acceptable timeframe.

Satellite: Currently, NDWC has a secure, always-on Internet link to INMARSAT, a London-based international telecommunications company that operates a fleet of geosynchronous telecommunications satellites. INMARSAT specializes in providing reliable communications services to a range of governments, aid agencies, media outlets, and businesses needing to communicate in remote regions or where there is no reliable terrestrial network. Services include traditional voice calls, low-level data tracking systems, and high-speed data services, as well as distress and safety services. NDWC uses the data transport feature of INMARSAT to relay alert notifications to 63 tsunami watchtowers along the Thai coast. This satellite contract with INMARSAT can be extended to feature inbound communications, wireless terrestrial communications, and other redundant agency-to-agency data links. Multiple independent satellite based services, with terrestrial backups would constitute a high availability option for satellite communications.

Email: Minimum requirement for email is reliable Internet access. Most NDWC staff utilize accounts with free web-based services, such as Yahoo and Hotmail, and could continue to use these accounts with just Internet access. However, an operational dedicated email server with

proper spam protection would be a superior option to free accounts (since these free email services do not provide any service guarantees). Email functionality could be made highly available within a Call Center application, such as the "eBusiness" suites offered by enterprise software companies. These applications typically integrate all data, voice, and fax and have business intelligence programming to transfer inbound messages to the most appropriate agent and keep track of messages received etc. This would provide better business information for effective decision-making and enable an adaptive enterprise for optimal responsiveness.

Media: NDWC has twelve (12) TV sets installed within the operations center, of which seven (7) where functional at the time of this assessment. This exceeds the minimum requirement of one television set and/or radio. A broadcast studio for media briefings is situated within the operations center as well. High- powered radio coverage, including AM/FM/SW would be a useful addition to access media broadcasts. Other media sources include news web sites featuring RSS ("Real Simple Syndication") which are popular web feed formats, specified in XML and used for (among other things) news web sites, weblogs, and "podcasting". This configuration can be upgraded to a "command center" with video and audio from all major media outlets and also outbound facilities, such as videoconferencing. Web-based products, such as Webex, will help conduct computer-driven presentations using PowerPoint for decision-making meetings. For maximum availability, NDWC should consider subscription to disaster specific wire and Internet services.

Internet (Connectivity): NDWC meets the minimal requirement of having broadband access (256Kbps) available to the Internet. Provided by Communications Authority of Thailand and Telephone Organization of Thailand , the DSL link is not always available. To effectively use data intensive applications, NDWC must install a reliable T-1 (1.5Mbps) link to the Internet. The Internet Service Provider (ISP) must guarantee reliability with downtimes scheduled in advance with NDWC. For dealing with real-time video and distributed database operations, the faster the connection the better. Hence, the high availability option would provide a T-3 (44.736 Mbps) link to the Internet. Regardless, there must be at least two (2) independent broadband class access links to the Internet, in case one of the ISP fails.

Dedicated Access (Wide Area Network): Except for the INMARSAT links to the tsunami watchtowers, there is no dedicated data transmission to or from NDWC. It's recommended that NDWC establish dedicated access mechanisms to various Thai agencies to facilitate emergency data transmission. A wide area network conforming to the Global Telecommunications Standard of NOAA, the World Meteorological Organization, or the recently instituted IOTWS would be the best WAN option for NDWC.

Internal LAN: The 10/100/1000 Ethernet at NDWC with redundant 54 Mbps wireless LAN (WLAN) exceeds the recommended requirements.

In general, the communication infrastructure meets or exceeds the minimum requirements, except for the dedicated access to inter-agency communications. Redundant communication lines and services are also highly recommended for most cases.

Computing Resources

In a minimal configuration, many services can be installed on a single machine that can multi-task between various types of requests. However, such a configuration is only useful for testing and proof-of-concept tasks. In an operational environment, logical services could still be "bundled" for a single machine, but care must be taken to load balance the services to avoid a) competing for system resources, and b) single point of failure. Therefore, the recommended configuration involves at least separating the database server from the rest for platform. For security purposes, it is best to separate the web server from the rest of the technology stack by a firewall.

General Office Computing Services: General office services, such as file and fax, are provided by relatively new Intel-based servers running Microsoft XP, while web services reside on a Sun 240 Unix server. Printing services are provided by a number of printers attached to the Intel-based XP client workstations (generally 2-3 workstations sharing a printer). As such, NDWC meets or exceeds the general office service's computing requirements. Redundancy clearly exists for printing services, but it is not optimal for other office services.

Application Services: At the time of the visit, there was no significant general and/or Disaster Management (DM) specific application present at the NDWC. The center, therefore, requires Unix-based application, database, and GIS servers (and associated services) to be deployed. Furthermore, DM applications are needed to integrate the said services, enhancing the overall capacity of the center.

Workstations: All client workstations are Intel-based computers, running Microsoft Windows XP and the Office suite of products. Generally, workstations are less than three (3) years old, and all are equipped with the Internet Explorer browser (required for the web-based access to the disaster information). There are also copies of (ESRI's) ArcView GIS Client applications on some of the workstations.

In general,

a) NDWC Servers and Services meet the minimum office, but fail to meet the minimum requirements for the DM applications, and must be augmented to meet the requirements.

b) The Client platforms meet and/or exceed the minimum requirements for most immediate needs (but may require enhancements for some disaster modeling applications).

Network Security, Processes, and Human Resources

While not directly required for the initial systems deployment, the following recommendations regarding networks security, system maintenance processes, and human skills are essential for NDWC's successful and continued operation. The ICT assessment briefly examines these components.

Network Security: The assessment team found common and periodic instances malicious software attacks at the NDWC. These programs (e.g., viruses, etc.) render the computer (and/or the network) useless to the point that they prohibit conducting any business in a reasonable timeframe. To remedy the problem, The Team recommends re-design of firewalls, installation of virus detection and prevention software, and utilization of email SPAM blockers on every client machine as well as the server equipment.

In general, NDWC fails to meet the minimum network and electronic security requirements.

Processes: At the time of the visit, NDWC's system maintenance and associated processes were not well developed. These processes include monitoring the network and applications for problems and outages, backup/recovery procedures (including off-site storage of critical data), and, in general, having redundancy provisioned for the network appliances. As related to network security and processes, software licenses inventories are needed to keep the software up-to-specifications, especially for application security patches to overcome recently discovered loopholes. Network traffic monitoring is also recommended not only to limit usage to official business, but also to detect unwanted intrusions and attempts to by-pass security.

In general, System Processes do not meet the minimum requirement standards required for the healthy operation and maintenance of the hardware and applications.

Human Resources and Skills: NDWC currently has an Information Technology (IT) Director and Webmaster. However, like other staff, they are deputized from other organizations where they hold full-time positions[5]. There are no dedicated full-time or contract staff to do normal day-to-day systems maintenance. The ideal scenario will have full-time specialized staff with several people cross-trained in various skills. The Team would have individuals responsible for Windows Administration, UNIX Administration, Database Administration, Software Support, and Data (GIS) and Modeling Analysts. It is recommended that NDWC would have at least one full-time person attending to all network and security administration, one person that can oversee the database

[5] Please note that by the time this document is ready for review, NDWC may have already acquired its own budget and resources.

administration, and software and workstation-related support, one Webmaster, and one or more person(s) dedicated to GIS data processing.

Key qualifications are described below (please note that, per above, multiple functions may be performed by the same person):

IT Director: Minimum of 12 years of experience in Information Systems, with at least seven years managing a small to medium IT Operations group.

Webmaster: At least two (2) years expertise in HTML, Java Scripting, XML, PHP/ASP/JSP to publish and maintain dynamic data content on NDWC public web site.

NT Administrator: Vital to have strong Microsoft NT, 2000, XP and above operating system knowledge, including include installation, configuration, and network set-up. Must be able to support secure, high availability system. Linux operating system a plus.

UNIX Administrator: Experience with Sun Solaris Unix system administration, LAN, and WAN based systems, high availability and clustering technologies.

Database Administrator: Experience in Oracle administrator to perform installation, maintenance, backups, and patching. Expert in SQL and PL/SQL. Monitoring and performance tuning knowledge. GIS experience a plus.

Software Engineer: Most maintenance and enhancements require good "scripting" programming (e.g., Unix shell, PERL, etc.) This is most applicable in extending the Dynamic Data Proccessor functionality to handle multiple hazards and automated processing of the warnings. However, software engineering knowledge including experience in software architecture, design, and development, and knowledge Java/JSP, C/C++ are strong pluses.

GIS Analysts and Modelers: Necessary for maintaining GIS and spatial data for the system and enhancing map service editing (using ESRI) software . Preferred skills include imagery analysis involving providing custom imaging and geo-coding of raw data for GIS analysis. Position to involve providing valuable analysis and analytical products and services using the third-party models that use GIS.

In general, NDWC is encouraged to enhance its human resources skills in these above areas.

Summary of Findings, Gaps, and Recommendations

Table 2 below, summarizes the findings, including gaps, and recommendations discussed in this report and with respect to the benchmarks. The "Checkmarks" represent the findings while the action columns reflect the views of the ICT expert team regarding next steps. The Immediate Gap column represents ICT gaps that are to be filled as soon as possible. Recommended Action column are those that require addressing in longer term (2-5 years).

		Benchmarks			Actions	
		Minimum	Recommended	High Availability	Immediate Gap	Recommended Action
Facilities	Server Room	√	√	√	None	Redundant Location to be considered long term
	Power	√	√	Backup Generator	Backup Generator	
	Operation Room	√	√	Multiple locations	None	
	General Rooms	√	√	√	None	
Communications	Phone	√	√	Redundancy	Better Configuration of PBX	Redundancy in telecomm provider (if possible), more fax dedicated fax lines, increase Internet bandwidth and reliability, establish dedicated circuits to partner agencies
	Fax	√	√	Redundancy	Test regularly	
	SMS	√	N/A	Redundancy	None	
	Satellite	N/A	√	Redundancy	None	
	Email	√	In-house capability	N/A	In-house email server	
	Public Media	√	N/A	N/A	None	
	Internet	√	√	Redundancy	None	
	Dedicated Access	Availability	Comm Redundancy	Data Redundancy	Establish with Partners	
	Local Area Network	√	√	Server Redundancy	None	
Computing Resources	Office Servers	√	Scalable	Stand-by	Stand-by equip	Scalable servers, implement High Availability for servers.
	Office Services	√	√	Stand-by	Stand-by equip	
	Specialty Servers	RDBMS, GIS, …	Stand-by	H/A Options	Large gap, None exist	
	Client workstations	√	√	Modeling apps	More GIS clients and modeling	
Network Security						
	General	√	Virus protection	Monitoring …	Virus protection & net monitoring	Detection & trending analysis
System Processes						
	General	Backup/restore	Off-site storage	Traffic monitoring	Large gap, Backup essential	Traffic monitoring
Human Resources						
	General	√	GIS Analyst	Modeling specialist	Gap in skills	FT staff

Table 2: Summary of the findings, gaps, and recommendations with respect to the benchmarks

Key Findings

In summary, this survey finds that, for the most part:

- NDWC's general ICT-related facilities meet or exceed the recommended specifications. This includes the Server Control room, Operations room, and related facilities within the building.
- NDWC's client computing environments, general office services, and the communication infrastructure meet or exceed the minimum requirements. This includes PC workstations, office suite, office file and print services, internal Local Area Network (LAN), and web and fax servers.
- NDWC's network (electronic) security and human resources and skills, however, are barely sufficient to meet the minimum requirements, and require considerable attention. System processes also are urgently needed to ensure business continuity and operations, especially, in times of emergency.
- ***But most importantly, and as it pertains directly to the scope of the TA contract, specialty application servers and services represent the biggest gap at the moment at the NDWC. The NDWC lacks basic automation of data processing that can greatly enhance its abilities to analyze events and issue warnings***.

Finally, it is appropriate to note that the NDWC also has a basic gap in establishing (dedicated) communication links to the supporting agencies. It is crucial to the operation of the warning center to have reliable connectivity to the (national and international) hazard data providers.

Other Key Recommendations

As noted above, the most important recommendation is fill in the gaps for application services (including GIS) to *establish a baseline for disaster data ingestion*, *automate data processing*, and *enhance the analytical capabilities of the warning center*.

Equally as important is establishing links and Memorandum of understanding with the national and international hazard data providers, such as those examined by this report, and/or USGS, NOAA, PTWC, JMA, etc.

Additional key recommendations:

- Investing in redundant communication paths (not necessarily vendors) to/from the NDWC. This ensures continual operation during emergency outages.
- Creation of "Highly Available" systems that have sufficient redundancy to guarantee that all key technical functions within the NDWC are always operational. This requires a dedicated team of full-time staff working for the NDWC on this issue.
- Establishment of industry-standard (and highly available) network security elements that are maintained by a qualified team of technical professionals. Network security elements include systems monitoring, firewalls, virus cleaning, spam filtering, backup/recovery and fail-safe redundancy.
- Investing in training both technical and non-technical staff on international languages to effectively communicate with foreign partners and counterparts. Regular "peer-to-peer" interactions over the hotlines must be integrated into exercises and drills to ensure that this process is functional during a crisis.

Recommended Hardware and Software

As evident by the above study, a major ICT gap that pertains to the scope of the TA contract is in the area of Specialty Servers and applications. As such, the expert team recommends filling this gap most immediately under the contract. Considering all above, and for the purposes of the proposed Decision Support Platform, The Team recommends the following minimum specifications:

Hardware	Purpose	Recommended Configurations			
		Model	CPU	RAM	Storage
Sun - Solaris 10	GIS Data Server and Oracle RDMS Server	V490	2x1.35Ghz	16 GB	2x146GB
Sun - Solaris 10	GIS Internet Map Server	V240	2x1.5 GHz	8 GB	2x73GB
Sun - Solaris 10	Daynamic Hazard Data Processor	V240	1x1.34 GHz	1 GB	2x73GB

Table 3: Recommended Hardware for the Proposed Decision Support Platform

Please note that the above hardware specifications in Table 3 are required for the proposed solution. If the hardware is to share load with other NDWC application, The Team recommends provisioning better models and specifications. For the this hardware, The Team also recommends the following software specifications:

Software	Purpose	CPUs	Comp
Arc-SDE	Spatial Data Engine - SDE	2	ESRI
Arc-IMS	Intenet Map Service	2	ESRI
Arc-Info	Desktop GIS App 1 seat	1	ESRI
Arc-View	Desktop GIS Viewing tool	2	ESRI
DBMS	Relational Databse Mgmt Sys	2	Oracle

Table 4: Recommended Software Specifications for the Proposed Decision Support Platform

Please note that above software applications will be supplemented by custom code provided by The Team. The custom code will take advantage of the above engines, as well as other open source applications to provide integrated services to the NDWC.

Finally, please note that this report identifies some key gaps regarding network security and staffing that need to be addressed, although they are not directly within the scope of this Technical Assistance contract.

For further information regarding this ICT Assessment, please contact the IT Director of the NDWC.

Appendix A – ICT Survey

Please note that this section is pending.